PASSIVE ENERGY SAVING SYSTEM FOR A BUILDING

RELATED U.S. APPLICATIONS

Not applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable.

REFERENCE TO MICROFICHE APPENDIX

Not applicable.

FIELD OF THE INVENTION

[0001] The present invention relates to a passive energy saving system for a building, and more particularly, to a passive energy saving system using the natural circulation of the two-phase flow to regulate the indoor temperature of the building, using the solar energy and the wind power to drive the indoor air circulation, using the solar energy to provide the warm water, and using the photo catalyst to purify air.

BACKGROUND OF THE INVENTION

[0002] The energy crisis occurred in the '70s raised people thoughts on replacing traditional fuels used for a building with solar energy, thus it accelerated the development of active solar energy heating system. But it was not until 1978 that the research of passive cooling system without power supply has been carried out. In recent years, the primary reason that the passive cooling technology has been paid great attention is that the peak electricity power consumption in summer is higher and

higher, and that the electricity power load of cooling air-conditioner is aggravating. Restraining peak electricity power consumption not only enables consumers to reduce electricity expense but also reduces the investment on power generation capacity. Furthermore, it is based on the consideration of long-term energy policy. It is hoped that through the promotion of passive cooling system or low-energy cooling system, the requirements on cooling air-conditioner can be reduced, thus the goal of saving energy and decreasing the greenhouse gas discharge can be achieved.

[0003] The goal of a building energy saving design is to realize natural ventilation, provide high-quality and comfortable indoor atmosphere environment, and reduce the requirements on energy cost of a building cooling system and heating system to be as low as possible. The conventional building energy saving technologies include: (1) reducing the solar radiation entering the building; (2) making use of solar energy for ventilation, air-conditioning, and providing warm water; and (3) making use of underground cooling energy saving system.

[0004] Some of the above-described energy-saving technologies have been described in patent documents. For example, WO 9,625,632 discloses the roof type air circulation system, US 4,934,338 discloses the wall-mounting air heater, US 4,418,618 discloses the solar energy warm-water supply system, US 2003/0037907 A1 discloses solar energy heat-pipe type heat exchanger, and US 4,373,573 discloses the energy saving system that saves solar energy in underground pipeline. However, the above-mentioned conventional technologies possess many disadvantages, which can be improved to promote the application of building energy saving and air-conditioner.

[0005] 1. The ground cooling energy saving system must be in coordination with the construction of a building, and a large quantity of cooling or warm-up pipelines must be buried under the deep ground beforehand. The outdoor air must pass through the underground pipelines to make the

temperature of air approach the underground temperature. The building ventilation system is then imported to adjust the indoor temperature, and thus the energy required by the cooling system (in summer) or heating system (in winter) can be reduced. Because the construction project of such energy-saving system is very large, the structure is complex and difficult for maintenance, and thus the investment needs a long return period.

[0006] 2. The conventional energy saving system requires to be brought into the integrated planning during the design of building, and in coordination with the construction sequence of building to complete the energy saving system. For the existing building, if the energy saving system is to be added, problems such as installation difficulty and cost increase will arise.

[0007] 3. The components of the conventional energy saving system lack modularized design, and they are quite difficult to be applied to the buildings with multifarious design to reduce the energy consuming of cooling system in summer and heating system in winter.

BRIEF SUMMARY OF THE INVENTION

[0008] The objective of the present invention is to provide a passive energy saving system using the natural circulation of the two-phase flow to regulate the indoor temperature of a building, using the solar energy and the wind power to drive the indoor air circulation, using the solar energy to provide the warm water, and using the photo catalyst to purify air.

[0009] In order to achieve the above-mentioned objective and avoid the problems of the prior art, the present invention provides a passive energy saving system for a building. The passive energy saving system includes a first reservoir, a heat exchanger positioned under the first reservoir, a first pipeline connecting the first reservoir and the heat exchanger, a heat-absorbing board positioned in

the building, and a second pipeline connecting the heat exchanger and the heat-absorbing board. The first reservoir comprises cooling water, the heat exchanger comprises a condensation pipe submerged by the cooling water, and the first pipeline transfers the cooling water between the first reservoir and the heat exchanger. The heat-absorbing board uses a fluid to absorb heat of air inside the building, and the second pipeline transfers the fluid between the heat-absorbing board and the heat exchanger.

[0010] The fluid in the heat-absorbing board vaporizes after absorbing air heat inside the building and the vapor flows to the condensation pipe in the heat exchanger passively through the second pipeline by buoyancy. The vapor is condensed into liquid by the cooling water in the heat exchanger, and the liquid then flows passively to the heat-absorbing board through the second pipeline by gravity. The temperature of the cooling water in the heat exchanger increases after absorbing air heat, while the density is decreased to flow upward to the first reservoir by buoyancy. The first reservoir can provide the cooling water continuously to the heat exchanger through the first pipeline.

[0011] Compared with the prior art, the present invention possesses the following advantages:

1. The passive energy saving system of the present invention can make use of the existing water storage facilities of the building, thus the construction engineering of the passive energy saving system can be simplified and the cost is reduced effectively.
2. The present invention makes use of the solar energy collector to heat air, the sunshine to illuminate photo catalyst to purify air, the hot water tank to absorb the solar energy, and the first reservoir to cool air. As a result, the solar energy collector of the present invention can be used to collect the solar energy effectively to make the indoor air clean and comfortable, and provide indoor with warm water without

consuming energy.

3. According to the present invention, all the constructive modules, such as the cooling module, the solar energy collector, the heat-absorbing board and the heat exchanger of the passive energy saving system, can be designed to be modularized, and can be flexibly assembled and positioned in the existing multifarious buildings. Furthermore, the entire system layout can be designed for large-scale buildings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0012] Other objectives and advantages of the present invention will become apparent upon reading the following descriptions and upon reference to the accompanying drawings in which:

[0013] FIG. 1 is a schematic diagram of a passive energy saving system according to the present invention;

[0014] FIG. 2 is a side view of a cooling module according to the present invention;

[0015] FIG. 3 is a cross-sectional diagram of FIG. 2 along the A-A section line;

[0016] FIG. 4 is a perspective diagram of a heat exchanger according to the present invention;

[0017] FIG. 5 is a cross-sectional diagram of the condensation pipe according to the present invention;

[0018] FIG. 6 is a schematic diagram of a solar energy collector according to the present invention; and

[0019] FIG. 7 is a schematic diagram of an air purifier according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0020] FIG. 1 is a schematic diagram of a passive energy saving system 10 according to the present invention. As shown in FIG. 1, the passive energy saving system 10 is built in a building 20, and includes a first reservoir 600, a heat exchanger 300 positioned under the first reservoir 600, a first pipeline 610 connecting the first reservoir 600 and the heat exchanger 300, a heat-absorbing board 200 positioned in the building 20 and a second pipeline 250 connecting the heat exchanger 300 and the heat-absorbing board 200.

[0021] The first reservoir 600 comprises cooling water, and the first pipeline 610 transfers the cooling water between the first reservoir 600 and the heat exchanger 300. The heat exchanger 300 includes a condensation pipe 320 that is covered by the cooling water in the heat exchanger 300. The heat-absorbing board 200 is positioned below the heat exchanger 300 and includes a fluid, such as coolant, to absorb air heat in the building 20. The boiling point of the coolant under a certain pressure is the temperature, such as 27 , that makes people feel comfortable. In addition, to be in conformity with the environmental protection regulation and reduce damage to the ozone layer, the coolant can be selected from R-25, R-32, R-125, R-134a and mixed with appropriate ratio. The coolant vaporizes after absorbing heat and the vapor flows upward to the condensation pipe 320 passively through the second pipeline 250 by buoyancy. The vapor is condensed into liquid through the cooling water in heat exchanger 300, and the liquid then flows downward passively to the heat-absorbing board 200 through the second pipeline 250 by gravity.

[0022] The passive energy saving system 10 can further include a cooling module 100 positioned on a window 121 under the heat-absorbing board 200 for cooling air entering the building 20. The cooling module 100 includes a cooler 140, a third pipeline 150 connecting the heat-absorbing board

200 and the cooler 140. The third pipeline 150 is used to transfer the coolant between the heat-absorbing board 200 and the cooler 140. The coolant in the cooler 140 vaporizes by absorbing air heat entering the building 20 and the vapor flows upward passively to the heat-absorbing board 200 through the third pipeline 150 by buoyancy. The liquid coolant in heat-absorbing board 200 reflows to the cooler 140 through the third pipeline 150 downward passively by gravity to absorb air heat entering building 20 continuously. In addition, the cooling module 100 can further include a photo catalyst filter 122 and an active carbon filter 123 for purifying air entering the building 20. In combination of the cooler 140, the third pipeline 150, the heat-absorbing board 200, the second pipeline 250 and the coolant in the condensation pipe 320 of the heat exchanger 300 together construct a two-phase natural circulation system to cool air entering the building 20.

[0023] The passive energy saving system 10 of the present invention can further include a second reservoir 11 positioned under the ground of the building 20, a fourth pipeline 13 connecting the second reservoir 11 and the heat exchanger 300, and a pump 12 for pumping the cooling water to the first reservoir 600 from the second reservoir 11 through the fourth pipeline 13 and the first pipeline 610. Because of the heat sink effect of underground, the temperature of the cooling water in the second reservoir 11 is lower than that in the first reservoir 600, and the cooling water required by the first reservoir 600 can thus be continuously provided by the second reservoir 11 according to the present invention.

[0024] Generally speaking, the building 20 includes a water tower or a fire fighting water tank on the roof, and an underground water storage tank is positioned under the ground of the building. The present invention can make use of the water tower or fire fighting water tank at the roof as the first reservoir 600, and make use of the underground water storage pool as the second reservoir 11, and

therefore the existing water storage facilities can be used in the passive energy saving system 10 of the present invention to supply water for the building 20. The first reservoir 600 supplies domestic water for the building 20 continuously, while the outdoor water supply system can refill water to the first reservoir 600 to maintain a predetermined liquid level, and therefore the cooling water in the first reservoir 600 is updated continuously such that it will not be overheated due to absorbing air heat in the building 20. The present invention adjusts the indoor temperature through the cooling water in the first reservoir 600 and achieves the reduction of energy required by the cooling system (in summer) and the heating system (in winter).

[0025] The passive energy saving system 10 of the present invention can further include an air circulation module, which comprises a first heat-exchanging pipe 620 positioned in the first reservoir 600, an air inlet 360 positioned in the building 20 and connected to an inlet of the first heat-exchanging pipe 620, and an air outlet 380 positioned in the building 20 and connected to an outlet of the first heat-exchanging pipe 620. The warm air inside the building 20 flows to the first heat-exchanging pipe 620 through the air inlet 360 by buoyancy. The cooling water of the first reservoir 600 cools the air, and it flows back into the building 20 through the air outlet 380 by gravity so as to provide a cooling air with a lower temperature. To improve the quality of air in the building 20, the air circulation module can include an air purifier 480 positioned between the air inlet 360 and the first heat-exchanging pipe 620.

[0026] In addition, the air circulation module can further include a solar energy collector 400 positioned between the air inlet 360 and the first heat-exchanging pipe 620. The solar energy collector 400 can heat up air passing therethrough to decrease the density of air to increase buoyancy, thus the air circulation for the building 20 is accelerated. Furthermore, the air circulation module

can further include a hot water tank 500 positioned between the solar energy collector 400 and the first heat-exchanging pipe 620, and a second heat-exchanging pipe 520 positioned in the hot water tank 500. Through the second heat-exchanging pipe 520, water in the hot water tank 500 can absorb air heat heated up by the solar energy collector 400, so that the hot water tank 500 can provide warm domestic water for the building 20 through an outlet 550.

[0027] The airflow in the air circulation module climbs upward with an elevation angle, and changes to downward inclination with a depression angle after leaving the air purifier 480. The warm air enters the hot water tank 500 at first and passes through the second heat-exchanging pipe 520 where a portion of heat is absorbed by water in the hot water tank 500. Air then enters the first reservoir 600 at the downstream and passes through the first heat-exchanging pipe 620 where a portion of heat is absorbed by the cooling water in the first reservoir 600, and finally enters the building 20 through the air outlet 380. Because the flowing air in the air circulation module absorbs the solar energy, its temperature increases and its density decreases so that it flows upward. Hereafter, through the two cooling process performed in the hot water tank 500 and the first reservoir 600, respectively, air flows downward passively due to the decreased temperature and the increased density, which construct an air circulation system driven naturally by the solar energy.

[0028] The design criteria for the first heat-exchanging pipe 620 and the second heat-exchanging pipe 520 are to possess a larger heat dissipation area, higher heat conduction efficiency, and the smallest possible airflow resistance. The shape of the airflow path for the heat-exchanging component complying with these criteria can be circular, elliptic, rectangular, strip, etc. In addition, it is contributive to achieve the optimal heat conduction effects between air and water by adding cooling fins with all kinds of shapes and with different arrangements in the airflow pipe wall, and

inserting all kinds of heat pipe or micro heat pipe in the airflow pipe wall. The cooling water entering the first reservoir 600 will sink to the bottom by gravity, while the cooling water at the bottom of the first reservoir 600 can absorb the air heat passing through the first heat-exchanging pipe 620 or absorb the indoor heat from the heat-absorbing board 200 through the heat exchanger 300. Once absorbing heat, the temperature of the cooling water at the bottom of the first reservoir 600 will increase and the density will decrease and force the cooling water to flow upward to the liquid surface. The first reservoir 600 can provide the warm water to the hot water tank 500 through a pipeline 510, while the first reservoir 600 includes a water outlet 650 at the bottom for providing the indoor cooling water.

[0029] When the solar intensity is not sufficient to drive the air circulation, the fan 643 can be activated to increase the airflow entering indoor. The function of the fan 643 is to increase the solar energy absorption efficiency of the solar energy collector 400, increase the solar energy absorption efficiency of the hot water tank 500, and increase the air-cooling efficiency of the first reservoir 600. If the solar intensity is sufficient or the natural circulation ventilation is adequate, the fan 643 can be turned off and let air enter indoor with natural circulation.

[0030] The air circulation module of the present invention can provide indoor either warm air or cooling air depending on the alternation of seasons by controlling the flow direction of air leaving the hot water tank 500. The air circulation module can further include a first control valve 540 positioned between the first reservoir 600 and the solar energy collector 400, a bypass pipeline 530 positioned between the solar energy collector 400 and the air outlet 380, and a second control valve 541 positioned on the bypass pipeline 530. When a cooling air is required to enter the building 20 during hot summer, the first control valve 540 is opened and the second control valve 541 is closed

so that the warm air become a cooling air after passing through the hot water tank 500 and the first reservoir 600, and finally the cooling air enters building 20. When the weather is cold with the need of warm air , the first control valve 540 is closed and the second control valve 541 is opened so that the warm air leaves the hot water tank 500 and bypasses the first reservoir 600, and finally enters building 20 directly through the bypass pipeline 530.

[0031] FIG. 2 is a side view of the cooling module 100 according to the present invention. As shown in FIG. 2, the cooling module 100 is positioned on the window 121 of the building 20, and includes a photo catalyst filter 122, an active carbon filter 123 and a cooler 140. The photo catalyst filter 122 is made of a photo catalyst fiber, which can generate hydroxyl free radical with powerful oxidation power to catalyze, decompose and remove any toxic substance such as bacterium, virus, dirt acrid, oil stain and carbon monoxide that may cause damage to human body. The photo catalyst fiber is preferably made of ZnO with a diameter in several nanometers, TiO_2 with a diameter in several nanometers, gold with a diameter in several nanometers, and silver with a diameter in several nanometers, etc. Most preferably, the diameter of photo catalyst material is smaller than 10 nanometers to have a better performance. The active carbon filter 123 is made of an active carbon fiber, whose function is to adsorb the odor and toxic substance in air, and which possesses advantages such as good air permeability, thin absorption layer, high absorption efficiency, and low cost.

[0032] FIG. 3 is a cross-sectional diagram of FIG. 2 along the A-A section line. As shown in FIG. 3, the cooler 140 includes a plurality of rhombus cooling pipelines 141 and coolant 145 in the cooling pipeline 141 for absorbing heat. The top of cooling pipeline 141 is connected to a header 142 (as shown in FIG. 2), which is connected to the bottom of the heat-absorbing board 200 through

the third pipeline 150. The coolant 145 in the cooler 140 absorbs the air heat with high temperature and vaporizes, and the vapor flows upward into the heat-absorbing board 200 (as shown in FIG. 1) by buoyancy. The liquid coolant in the heat-absorbing board 200 flows back to the cooler 140 by gravity to form two-phase natural circulation flow, which transports the heat of outdoor air to the heat-absorbing board 200 and the heat is then dissipated to the first reservoir 600 through the heat exchanger 300.

[0033] FIG. 4 is a perspective diagram of the heat exchanger 300 according to the present invention. As shown in FIG. 4, the heat exchanger 300 is full of cooling water 330, and the condensation pipe 320 is positioned inside the heat exchanger 300 and is submerged by the cooling water 330. The function of the heat exchanger 300 is to condense the coolant in vapor phase within the condensation pipe 320 into liquid phase. The cooling water 330 in the heat exchanger 300 absorbs heat from the pipe wall of the condensation pipe 320, and the absorbed heat is further transferred to the first reservoir 600 through the natural circulation of the cooling water 330.

[0034] FIG. 5 is a cross-sectional diagram of the condensation pipe 320 according to the present invention. The design criteria for the condensation pipe 320 are to possess a larger heat transfer area and lower manufacture cost, and the condensation liquid can flow back to the heat-absorbing board 200 by gravity (as shown in FIG. 1). As shown in FIG. 5, the vapor 328 in the condensation pipes 320 contacts with the pipe wall 322 and condensates into a liquid film 327, which can flow downward by gravity. The cooling water 330 outside the condensation pipe 320 flows upward to the first reservoir 600 through the first pipeline 610 by the buoyancy because its temperature increases and its density decreases after absorbing heat from vapor 328, while the cooling water 330 in the first reservoir 600 flows into the heat exchanger 300 by gravity because of its larger density.

As a result, the present invention can remove the indoor heat of the building 20 to the first reservoir 600 through natural circulation of the cooling water.

[0035] FIG. 6 is a schematic diagram of the solar energy collector 400 according to the present invention. As shown in FIG. 6, the solar energy collector 400 includes a top cover 402, a heat-absorbing plate 405 and a plurality of helical coils 415 connected to the heat-absorbing plate 405. The top cover 402 of the solar energy collector 400 is composed of glass plate or transparent plate, and the heat-absorbing plate 405 is composed of black metal board to collect solar energy effectively. There is a heat collection space 403 between the top cover 402 and the heat-absorbing plate 405, and there is an airflow channel 411 below the heat-absorbing plate 405. Air from the air inlet 360 enters the entrance 401 of the solar energy collector 400, passes through the entrance space 410, and flows to the airflow channel 411 inside the helical coils 415 where air is heated to be warmer. The warm air is collected by the outlet space 412, and then flows out of the solar energy collector 400 through the outlet 413.

[0036] The helical coils 415 of the solar energy collector 400 are thermally connected to the top and bottom of the airflow channel 411. The primary function of the helical coils 415 is to efficiently conduct the high temperature of the heat-absorbing plate 405 to the bottom of the airflow channel 411 by the high thermal conductivity characteristics, and thus makes the temperature of air in the airflow channel 411 distribute uniformly and increases the absorbed solar heat energy. Another function of the helical coils 415 is to improve the heat-absorption capability of air. When air passes through the airflow channel 411 inside the helical coils 415, the geometry of the helical coils 415 will result in the air whirlpool and accelerate the turbulence of air to improve the heat-absorption capability. The design criteria for the helical coils 415 are that the material possesses characteristics

such as high conductivity and corrosion resistance such as copper, aluminum, stainless steel, while the coil can be used different shapes such as circular column, square column, strip, etc. The outer diameter of the helical coils 415 must have contact with the top and bottom of the airflow channel 411 directly, and its channel axis must be in parallel with the direction of airflow channel 411.

[0037] FIG. 7 is a schematic diagram of the air purifier 480 according to the present invention. As shown in FIG. 7, the exterior of the air purifier 480 is a transparent box 483, the interior is a transparent pipe 482, and air is between the exterior and interior. The transparent pipe 482 includes a fiber-knitting wall 481 positioned in parallel with the flow direction of air, and there are air channels 485 between fiber-knitting walls 481. The sum of the cross-sectional area of the air channel 485 in the transparent pipe 482 should be larger than the flow cross-sectional area of the pipelines entering the air purifier 480, so that the flow resistance of air purifier 480 can be reduced to allow air to pass therethrough. The composing material of the fiber-knitting wall 481 includes active carbon fiber and photo catalyst. Sunlight can penetrate the transparent box 483 and pipe 482 and illuminate the fiber-knitting wall 481 directly to generate hydroxyl free radical with powerful oxidation ability, thus it catalyzes to decompose and remove the toxic substance to human body.

[0038] Compared with the prior art, the present invention possesses the following advantages:

1. The passive energy saving system of the present invention can make use of the existing water storage facilities of the building, thus the construction engineering of the passive energy saving system can be simplified and the cost is reduced effectively.

2. The present invention make use of the solar energy collector to heat air, sunlight to illuminate photo catalyst to purify air, the hot water tank to absorb the solar energy,

and the first reservoir to cool air. As a result, the solar energy collector of the present invention can be used to collect the solar energy effectively to make the indoor air of the building clean and comfortable, and provide indoor warm water without consuming energy.

3. According to the present invention, all the constructive modules, such as the cooling module, the solar energy collector, the heat-absorbing board and the heat exchanger of the passive energy saving system, can be designed to be modularized, which can be flexibly assembled and positioned in the existing multifarious buildings. Furthermore, the entire system layout can be designed for large scale building.

[0039] The above-described embodiments of the present invention are intended to be illustrative only. Numerous alternative embodiments may be devised by those skilled in the art without departing from the scope of the following claims.